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Learning from International Comparisons Across Decades

DORTE VERNER

European University Institute, Florence

EUROPEAN UNIVERSITY INSTITUTE, FLORENCE

ECONOMICS DEPARTMENT

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BADIA FIESOLANA, SAN DOMENICO (FI)

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European University Institute
Badia Fiesolana
I – 50016 San Domenico (FI)
Italy

CAN THE VARIABLES IN AN EXTENDED SOLOW MODEL BE TREATED AS EXOGENOUS?

LEARNING FROM INTERNATIONAL COMPARISONS ACROSS DECADES

Dorte Verner[1]

Department of Economics
European University Institute
C.E.N. 2330
50100 Firenze Ferrovia
Italy
Verner@datacomm.iue.it

Abstract

This paper analyses the underlying assumptions of an extended Solow model. The hypothesis that the explanatory variables are weakly exogenous for the parameters of interest is tested. Additionally, it is studied if the same growth model is valid across time periods when economic growth and the various types of investment are modelled simultaneously. The results of the study are that human capital, investment, and fertility are weakly exogenous in the 1983-90 period but not in the 1974-82 period. Furthermore, growth is found to Granger cause school enrolment, investment, and fertility. Finally, the same model does not apply for the different sub-periods under study, that is, one cannot pool the data.

Keywords: Economic growth, fertility, human capital, investment, simultaneous systems of equations, pooled data analysis.

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Why are some countries poor and other countries rich? That is to say, what determines the "Wealth of Nations?" These questions are essential and have troubled economists since the time of Adam Smith. In Smith (1776) the mercantile view, according to which a nation's accumulation of gold and silver is equivalent to an increase in its wealth, is challenged. Smith argues instead that the wealth of an economy is measured by the productivity of its labour force. If Smith's definition of the wealth of countries is accepted, the per capita gross domestic product automatically becomes the most suitable means of measuring the wealth of a nation.[2]

In recent years, theoretical and empirical work on economic growth has reappeared on the macroeconomic agenda. However, the process of economic growth is far from being fully understood. Wide differences still exist between the mentioned *levels* of the gross domestic product of various countries. This is widely recognised, but cannot, nevertheless, be mentioned often enough. For example, in the US the level of real gross domestic product per capita was 18,399 US dollars in 1990 against Ethiopia's 297 US dollars. This is a difference of more than *factor 60 in the living standard.*

Growth rates of real per capita GDP are also diverse. Over the period 1966-1985, it was observed that countries in Africa experienced very low or even negative growth rates in per capita income, for example Mozambique and Angola experienced on average a negative growth rate of 3 per cent annual per capita income. On the other hand, some countries in Asia experienced very high growth rates in per capita income, for example Singapore and Hongkong, which had on average 7 and 5.4 per cent positive growth rates respectively over the period. In essence, this means that *income will double every 10 years in Singapore*, whilst it will be *halved every 22 years* in the aforementioned African countries. These figures are at least as striking as the differences in income levels.

[2] A cautionary remark needs to be added here: per capita GDP and growth in per capita GDP contributes to the potential for welfare and for standards of living, but it is not the same thing. Standards of living can move in the opposite direction if the resources released by e.g. productivity growth do not find adequate employment in other activities including e.g. leisure.

Are there any consistent economic explanations for the facts that can be observed across countries? The answer is, so far, no; in order to establish these, we need to analyze the determinants of growth. In the Solow (1956) model extended by for example. human capital (see e.g. Barro (1991) and Mankiw, Romer and Weil (1992)) the underlying assumption is that the explanatory variables are weakly exogenous. This paper will examine if this is really the case when the endogenous variables are the real GDP per capita growth rate, investment, human capital, and fertility. This last variable does not have a prominent role in the literature; in this paper, however its importance as a determinant is emphasized.

First, we will consider the implications of the explanatory variables being **non-exogenous** in the extended Solow growth model. If the determinants of growth are not exogenous, then for the purposes of inference, the extended single equation empirical Solow model is invalid, and a large part of the existing empirical literature can be questioned. This study might also clarify the contemporary conundrum regarding the question whether higher growth precedes higher investment, a lower fertility rate, and higher human capital accumulation. Put simply, the question is: does a "reverse" effect also exist as a result of output growth to these different kinds of "investment"? This **leads to the following questions which are put forward in this paper:**

-- a) Are the regressors in a fully specified extended Solow model - human capital, physical capital investment, and fertility - really weakly exogenous?

-- b) Is there really no causation from (lagged) growth to these variables? Causality could be the result of the dynamic response of the economy to shocks. A negative transitory shock to growth may be spread via an investment response. That is to say, the dynamics of growth where low growth lowers the investment rate, further lowering growth, etc..

-- c) Is the same empirical growth model valid across different time periods, or formulated in another way, can panel data studies be directly used to gain information about what determines economic growth?

The questions will be answered by means of empirical studies by modelling both economic growth and the various types of investment simultaneously. The model will be gauged by a cross-country time series dataset based on data for more than 100 countries for the 1965 to 1990 period.

We will further consider **conditional convergence**. That is to say, do poor countries tend to catch up with rich countries if the determinants of a steady state are taken into account? The analysis of convergence is an integrated part of the above mentioned studies.[3] Could this analysis not be made to reveal new insight into the question of whether poor countries tend to grow faster than rich countries in the 70s and the 80s?

The results of the empirical studies for the 70s and 80s will now be summarised. *First*, the hypothesis that human capital, investment, and fertility are weakly exogenous for the parameters of interest in the extended Solow growth model in the 1983 to 1990 period cannot be rejected. However, the aforementioned hypothesis can be rejected for the 1974 to 1982 period, concerning investment share in GDP. This means that the marginal distribution of the conditioning variable --investment-- has to be modelled. *Second*, growth Granger caused school enrolment, investment, and fertility. When growth rises, the level of, say, education subsequently also rises. This result is an additional reason to explain why growth studies are important. Surprisingly, more education did not lead to a statistically significantly higher growth in the 1980s, although it did in the 70s, as no direct effect from the secondary school enrolment is revealed. *Third*, poor countries are capable of catching up, i.e. β-non-convergence can be rejected for either of the two sub periods. *Fourth*, an important result from this study is that fertility is strongly negatively correlated with economic growth. That is, the lower the fertility of a woman in her fertile age in a country, the more that particular country will grow. *Fifth*, the negative partial correlation between fertility and growth show that fertility is an important factor in the determination of economic growth. It seems reasonable that fertility captures the low growth performance of the African countries in the 70s and the 80s.

[3] The results of e.g. Mankiw, Romer and Weil (1982) and Quah (1993) are contradictory, so it is still unclear if convergence exists.

Additionally, it should be noted that there is no sign of misspecification such as for example vector: non-normality, serial correlation when ordered by initial income level and heteroscedasticity in the model when data for around 100 countries are applied. *Finally*, the **same model of economic growth does not apply for the different sub periods under study**, and, therefore, the existing literature applying traditional panel data and cross-section analysis should be interpreted with prudence.

This paper will be structured as follows: Section Two will contain a brief survey of the growth literature. Section Three will include ways in which the above questions are investigated. Section Four will describe the nature and sources of the data analyzed. Finally, Section Five will provide results and Section six concludes. Additionally, three appendices will be included: Appendix A, listing the countries in the data samples. Appendix B, identifying the data sources and definitions of the variables. Appendix C, presenting the results.

2. A survey of the growth literature

The recent revival of interest in economic growth has not only been of a theoretical nature, for a substantial amount of empirical literature on cross-country comparisons has been published. The purpose of this section is therefore to very briefly summarise this empirical literature.

2.1 Empirical growth studies

The empirical studies of economic growth have mushroomed in the last few years. The two main issues in these studies relate to the attempt to discover the determinants of growth performance and analyze, therefore, whether convergence exists. Recent research has been carried out by means of a single equation growth model and mainly by cross-section data. A couple of panel data analyses have also been undertaken (see e.g. Knight at al. (1993), Barro and Lee (1993), and Verner (1993)), but this area remains largely unexplored. However, because the authors study different sets of countries, with aggregates of different years and different explanatory variables, the cross-country growth studies are not very homogeneous. The plethora diversity makes it difficult to discern consistent relationships and compare the results of studies. The basic equation applied in the empirical literature[4] is the extended Solow regression model:

$$g_{it,t-T} = a + by_{it-T} + cx_{it,t-T} + \varepsilon_i \tag{1}$$

where y_{it-T} is per capita GDP at time t-T in country i and $x_{it,t-T}$ is a vector of explanatory variables (averages from t-T to t) that is supposed to determine the growth rate of per capita income, $g_{it,t-T}$, in the period from t-T to t. The initial level of income, y_{it-T}, can be interpreted as a proxy for the relative income variable that captures the different levels of technological progress. The vector of explanatory variables contains variables such as physical capital investment, population growth, proxies for human capital, political stability, public inventions, market distortions, etc.. In (1), the variables in $x_{it,t-T}$ are treated as independent variables and are assumed to be weakly exogenous.

The convergence hypothesis has received considerable attention over the last few years (in (1) the only regressor is the initial income level). Baumol (1986) found evidence that poor countries grow faster than rich, but De Long (1988) argues that this is due to the ex-post sample selection bias because, since the data was expanded to include countries that ex-ante appeared rich, the evidence of convergence vanished. This illustrates that ex-post it is possible to identify "convergence clubs" among groups of countries but it hardly justifies generalised convergence. Most of the recent empirical literature shows that between 1950 and 1985, poor countries did not grow faster than rich countries. In fact, the point estimate on the initial GDP in the univariate regression often turns out to be significantly positive (see e.g. Mankiw, Romer and Weil (1992)). The unconditional convergence hypothesis can further be criticised because a negative correlation between initial income and subsequent growth rates need not imply the global convergence of all countries to the same level of per capita income. Instead, it might reflect a merely local convergence to a number of distant

[4] See also Sala-i-Martin (1993a) where a similar model is outlined.

income levels, and thus different steady states, as pointed out by Durlauf and Johnson (1992). If one restricts the analysis to homogenous groups of economies --like regions in a country-- unconditional convergence is observable (see e.g. Barro and Sala-i-Martin (1990), Sala-i-Martin (1993)[5].

The absence of a negative point estimate on initial GDP level in the univariate regression model made the endogenous growth theorist claim that the Solow growth model had failed[6], since there would be non-decreasing returns to capital. Barro and Sala-i-Martin and Mankiw, Romer and Weil rescued the neoclassical hypothesis by pointing out that the growth rate of an economy would be inversely related to its steady state. Convergence may take place ($b<0$ in (1)) if one corrected the differences in the $x_{it,t-T}$ in (1) and interpreted the variables in $x_{it,t-T}$ as proxies for the steady state. Conditioning on different savings rates, levels of technology etc., led to the growth rate of an economy being inversely related to the distance from its steady state. Some important results obtained in the empirical literature are summarised in Table 1. They are:

-- 1) physical capital investment and human capital (proxied by school enrolment rates and life expectancy) are both significant explanatory variables and positively correlated with economic growth per capita. The countries with a higher physical capital investment share and a high secondary school enrolment rate which indicate an educated work force are predisposed to grow faster than a country with low;

-- 2) β-non-convergence can be rejected when the determinants of steady state are taken into account[7];

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[5]Barro and Sala-i-Martin (1992) named this β-convergence to distinguish from σ-convergence, as defined by Quah (1993), as the reduction of the dispersion of income across countries over time.

[6]If one studies multiple sector endogenous growth models and decreasing returns are present in one of the sectors, the model can be said to allow for convergence.

[7]However, the question whether is correct way to measure convergence in this way can be discussed, see e.g. Quah (1993).

-- 3) different measures of political instability and market distortions hinder growth;

-- 4) population growth and per capita output growth are not systematically negatively correlated;

-- 5) the introduction of continent dummies for sub-Saharan Africa and Latin America reveal that the model cannot fully explain the growth experience in these regions, which is to say, some regularities are missing for this group of countries in the applied model.

A recent paper by Easterly, Kremer, Pritchett and Summers (1993) claims that the above studies by shedding light on country characteristics as determinants of growth are misleading because these characteristics are very persistent while growth rates are not. Terms of trade shocks, in particular, explain just as much of the variations in income growth rates as do the policies performed by the countries. Therefore, one should be careful in ascribing high growth rates to good policy.

According to Levine and Renelt (1992), more than 50 explanatory variables have been found to be important in the determination of growth. This led these authors to analyze the robustness of the results by applying Leamer's extreme bound test applying cross-section data[8]. They found that most of the findings were fragile to small changes in the conditioning set when a cross-country sample from 1960 to 1989 was used. The only exceptions were the investment share and the initial level of income. Additionally, they concluded, without being specific, that some collections of policy variables are important.

[8]The growth rate is regressed on a set of base variables, policy variables and supplementary variables. One changes the included supplementary variables until the parameter of the policy variable becomes either insignificant or changes its sign. If this happens the policy variable of interest is according to this analysis said to be fragile. Otherwise it is said to be robust.

TABLE 1
SUMMARY OF SOME GROWTH REGRESSIONS

author	datasource	dataform	countries	explanatory variables
Kormendi & Megurire (1985)	Int. Financial st. (IMF) 1950-	cross-section	47	POPG(+) GDPINI(-) OPEN(+) MON(+) GOVC(-) INFLG(-) I(+) LIBERTY(+)
Barro (1991)	Summers & Heston	cross-section	98	GDPINI(-) ENR1INI(+) ENR2INI(+) GOVC(-) REV(-) ASS(-)
Mankiw, Romer and Weil (1992)	Summers & Heston	cross-section	98	GDPINI(-) ENR2(+) I(+) $(n+\delta+g)$(+)
Barro & Lee (1993b)	Summers & Heston, own data on human capital	cross-section and decade-panel (1965-75 & 1975-85)	95 & 85	GDPINI(-) ♂ENR2(+) ♀ENR2(-) LIFE(+) I(+) G/Y(-) BMP(-) REV(-)

Note: The table presents essential results from the growth regressions where GDPINI is initial per capita GDP level, I is domestic investment share in real GDP, ENR2 is male and female secondary school enrolment rates, ♂ENR2 is only male, ♀ENR2 only female, LIFE is the life expectancy rate, G/Y share of government spending in GDP, BMP is the black market premium on exchange rates, REV is the number of revolutions and coups, $(n+\delta+g)$ is the population grow rate (also POPG), rate of capital depreciation and exogenous growth rate, GOVC is government consumption, ASS number of assassinations, INFL G is the growth rate of inflation, OPEN is the growth rate of export to GDP, MON money supply growth rate, LIBERTY an index of civil liberty, ENR1INI initial enrolment rate in primary school. The (+) means that the variable is positive correlated with growth.

2.2 Discussion of the empirical growth literature

In this sub-section the methodological and analytical problems of cross-country studies will be briefly discussed[9]. One of the main criticisms of the empirical growth modelling is that t-statistics and goodness of fit have been the dominant model selection criteria. Further, that the literature suffers from a lack of reporting on diagnostic tests such as e.g. tests for homoscedasticity, functional form, normality. Additionally, other tests -- needed to test if the model is congruent with available information -- are not reported. This includes tests for exogeneity.

Many regression models are presented by various authors and on many topics such as e.g. fertility, investment and growth (see e.g. Barro (1991) and Cohen and Hammour (1993)). These single equation models could make seems to imply that the researchers consider these endogenous variables to be related. Therefore, it seems interesting to both model economic growth and the various types of investment simultaneously. Attempts have been made to solve the problem of exogeneity. Barro (1991) mentions that the assumed exogeneity of regressors in the equations can be questioned and estimates the growth rate and the investment ratio, i, (among others) separately

$$g_{it,t-T} = \alpha_1 + \alpha_2 x_{it,t-T} + \varepsilon_{gi} \quad \wedge \quad i_{it,t-T} = \beta_1 + \beta_2 x_{it,t-T} + \varepsilon_{ii} \tag{2}$$

where $i_{it,t-T} \notin x_{it,t-T}$. Barro (1991) finds a correlation between the residuals in the two equations which leads him to estimate

$$g_{it,t-T} = \gamma_1 + \gamma_2 x_{it,t-T} + \gamma_3 i_{it,t-T} + \varepsilon_i \tag{3}$$

which is a *particular* linear combination of a system of equations and, unfortunately, test of the restrictions imposed are reported in the aforementioned papers.

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[9]Mankiw, Romer and Weil's assumption that *all 98 countries* in their study have the same common rate of technological progress over a 25 year period is simply unjustifiable. (i.e. compare Japan and Chad). Other recent authors have provided empirical evidence of the importance of human capital. Azariadis and Drazen (1990) found that most countries were not able to grow quickly during the postwar period without a highly literate labour force. They interpreted this as evidence that there is a threshold externality associated with human capital accumulation.

3. Weak Exogeneity and Causality

In this section it will be pointed out why the questions on exogeneity and convergence seem to be some of the most urgent issues in research on economic growth[10]. Strong exogeneity requires weak exogeneity and Granger non-causality (Engle, Hendry and Richard (1983)). If the explanatory variable is not weakly exogenous for the parameters of interest, then the marginal process generating this variable has to be modelled. This can be done by specifying the joint model (simultaneous equation system). Therefore, using a single equation approach requires that the explanatory variables are weakly exogenous. If the variables are not weakly exogenous, valid inference can only be made on the basis of a simultaneous estimation of equations. Furthermore, if the explanatory variable is Granger caused by the dependent variable, strong exogeneity is not fulfilled.

3.1 Exogeneity modelling

The theory of weak exogeneity is now described, and defines those cases where conditioning is valid from those where it is not. The concept of weak exogeneity applies cases in which there is no loss from ignoring information in the marginal distributions of the conditioning variables. Exogeneity modelling can be seen as an attempt to clarify if the statistical data used in studying economic growth allow us to model the GDP growth rate without modelling the determining variables (e.g. investment) i.e. the marginal process. If a certain explanatory variable is not weakly exogenous, it should be modelled within the system and therefore some of the imposed zero restrictions may not be valid restrictions. The aforementioned empirical linear growth models treat the regressors as if they were (weakly) exogenous for the parameters of interest (c in equation (1)). Rewrite (1) as

$$g_{it,t-T} = \beta' z_{it,t-T} + \epsilon_i \tag{4}$$

This regression is the conditional expectation of $g_{it,t-T}$ given $z_{it,t-T}$ (denoted $E[g_{it,t-T}|z_{it,t-T}]$). Taking the conditional expectation gives us $E[g_{it,t-T}|z_{it,t-T}] = \beta' z_{it,t-T}$ where β is the parameter of interest. A condition sufficient to sustain this interpretation of (4) is a joint multivariate normal distribution for $(g_{it,t-T}, z_{it,t-T})$ with $z_{it,t-T}$ weakly exogenous for β. Let us now formalize weak exogeneity. Its importance is that

[10]To analyze these questions I apply, in general, a methodology based on general-to-specific modelling, as this approach takes explicit account of the possibility that the empirical growth model is a structural model rather than a single equation.

regressors treated as conditioning variables must be weakly exogenous to sustain efficient and valid inferences (see Engle, Hendry, and Richard (1983)). To simplify, we shall consider a bivariate system, and the two variables are g and z --where time and country notation is suppressed for simplicity. The joint density, D(g,z), of g and z can be factored into the marginal distribution, D(z) (the process which generates z), and the conditional distribution, D(g|z)

$$D(g,z) = D(g|z)\,D(z) \tag{5}$$

The parameters λ of the joint density can be partitioned into $\lambda=(\lambda_1:\lambda_2)$ and, therefore, (6) rewritten as

$$D(g,z|\lambda) = D(g|z,\lambda_1)\,D(z,\lambda_2) \tag{6}$$

where no restrictions are imposed and hence there are no losses of information. Some parameters, say θ, are the focus of the econometric modelling activity and these are therefore called parameters of interest. If one wants to avoid losses of information from modelling only the conditional relation in (6), it is necessary to obtain knowledge about θ from the factor

$$D(g|z,\lambda_1) \tag{7}$$

alone. The resulting knowledge about θ must be the same as the information which could be obtained from analyzing the marginal *and* the conditional distribution collectively. This is the joint density, D(g,z|λ). Let us now turn to question of which conditions can ensure this and therefore the weak exogeneity of z

1) All parameters of interest, θ, can be obtained from λ_1 alone; and

2) λ_1 and λ_2 must be variation free[11].

If both these two requirements are fulfilled then z is said to be weakly exogenous for θ and only the conditional model needs to be estimated since the marginal model contains no extra information about θ which is not already in the conditional model (see Ericson (1992)). When modelling, this in practise means that there should be no cross-restrictions between the parameters of the two parts of the model and no relation between the error terms of the structural model and

[11]They must operate a sequential cut, that is impose no restrictions on each other.

the recursive part of the system. If it is the case that weak exogeneity is not sustained, but that the parameters of interest are identifiable, the joint density must be analyzed to ensure efficient inference.

3.2 Testing exogeneity

It cannot generally be assumed, a priori, that a variable is (weakly or strongly) exogenous, therefore, it is essential to test it. In the context of the growth models this leads us to the following questions: Are the regressors in the extended Solow model --human capital, physical capital investment, and fertility-- weakly exogenous? Is there no causation from (lagged) growth to these variables? Causality in this direction could be caused by the dynamic response of the economy to shocks. One example could be that a negative transitory shock to growth may be spread via human capital response: low growth lowers the investment rate, further lowering growth.

The econometric set up is a simultaneous system of equations. The tests for exogeneity will be rendered establishing that no null hypothesis can be rejected when performing the misspecification tests (homoscedasticity, normality etc.) for each of the single equations as well as the whole system. The tests for weak exogeneity are performed by estimating and saving the residuals for each equation of the system. Moreover, one must reduce and test any overidentifying restrictions. If the restrictions imposed are not rejected, then the unlagged explanatory variable and the residuals from the respective equations of interest are inserted into the growth equation. If the estimated coefficient on the residuals is insignificant, then the null hypothesis that the relating endogenous variable is weakly exogenous is not rejected. In this case, the marginal process can be left unmodelled. If, in addition, the lagged dependent variable e.g. the growth rate is insignificant in, for example, the equation for fertility growth (growth does not Granger cause fertility) then the null that the fertility rate is strongly exogenous is not rejected either.

The suggested way of solving the difficulty of endogeneity in the cross-country studies might therefore also be able to clarify the relationship between growth and investment, and human capital and demography. It would be appropriate to ask if the causation runs from investment in its broad sense to growth in output, or alternatively, does investment keep the capital output ratio constant? If it takes some time to adjust savings following a shock - e.g. an oil-price shock - we might see that a change in the investment rate; as followed by growth rate in output. Similarly, if it takes time for investment to become productive, one could anticipate first a change in the investment and only later a change in the growth. The answers to these questions will be found as a result of a simultaneous estimation of equations.

3.4 The Modelling

The first step in the analysis will be to set up a model based on the an extended Solow model. The different elements in this model - human capital, physical capital investment and fertility - will be modelled additionally. The idea behind the choice of variables[12] to be included in the simultaneous equation system is that: First, fertility rate is determined by child , education and initial income level. Second, physical capital investment is determined by education, the price of investment goods relative to prices abroad and the degree of openness in the economy. Third, education is determined by the proportion of the population living in urban areas and the initial level of per capita income level.

Additionally, life expectancy at birth and the pupil to teacher ratio are introduced into the regressions. The latter indicates the quality of education and the former might pick up if a country has a "good" government Life expectancy might also capture other things not included variables like health care and culture where, especially, culture is difficult to proxy by economic variables. Barro and Lee (1993) describe it as human capital, i.e. it stands for something else. In the following is outlined a brief theoretical explanation of the introduction of the explanatory variables into the modelling.

At the aggregate level, human reproduction is the ultimate source of an economy's labour input. At the individual level, children are a source of security for when people retire in developing countries. Furthermore, children compete with alternatives for parental resources of time and money available. Among the striking regularities in the aggregate cross-country studies of demography are the inverse relations between fertility and income per capita, or between fertility and the level of human capital. As a rule, high-income countries have been characterized by low fertility and high levels of human capital. In the past 25 years, the countries that have experienced high rates of per capita income growth have also experienced relatively rapid declines in fertility and rapid increases in human capital levels. The reason for introducing education is the theoretical argument that the more human capital is accumulated per person, the lower the

[12]The introduced explanatory variables are by parts inspired by the world bank project of Cohen and Hammour (1993) (where I was a research assistant).

fertility rate is (Becker, Murphy and Tamura; 1991). Higher fertility increases the value of parents' time and thereby, the cost of raising children. Infant is introduced as a determinant of childbearing since net fertility is more important than gross fertility.

The theoretical explanations behind the variables that determine *investment* are that: 1) higher price of investment goods may reduce the investment demand, 2) a higher degree of openness means wider access to foreign goods, which raises investment opportunities, since firms in a more open economy have access to a wider range of intermediate products, which can factor a decline in the production costs (see e.g. Grossman and Helpman; 1991). On the other hand, a more open economy also means more foreign competition, which might reduce domestic investment opportunities. Finally, 3) a high level of education might stimulate investment, if the productivity of physical capital rises with education levels.

The theoretical justifications for introducing the explanatory variables for *education* are that the demand for education can be expected to be higher in urban areas (see e.g. Schultz; 1985) and, regarding GDP, richer countries can supply more education[13].

4. The data

The dataset proposed for the empirical studies outlined above contain over 100 countries and three time-periods (listed in Appendixes A and B). The following describes the datasets applied in the empirical growth studies, as well as other statistical and conceptual issues associated with constructing and measuring the data.

Why, when research in this field has been undertaken by so many economists, has there been so little progress in understanding the mechanisms for producing growth? Could it be the availability and quality of the applied data? The variations in national statistical practice reduces the comparability of data. For example, at the national income accounts level there are definitional problems about the borders of activity (e.g. home production) and measurement problems associated with the existence of the underground economy (black markets). One

[13]The empirical results which will be reported may perhaps not be interpreted as structural estimates of a well-defined model, but rather as an investigation of empirical regularities in data.

of the largest problems is, perhaps, the measurement of real output in constant prices and, therefore, the associated growth measure. Output is deflated by a price index. The quality of these measures is related to the quality of the price data (where some prices are regulated, controlled or subsidised. Furthermore, the "quality change" problem exists). Therefore, it is not possible to treat errors of measurement at the aggregate level as being independent across price and quantity measures. Although every effort has been made to standardise the data, full compatibility cannot be ensured and thus care must be taken in interpreting the indicators. They should be interpreted only as indicating trends and as characterising major differences among countries, rather than as precise quantitative indicators of those differences.

One should note that even when data are made comparable not all the features of an economy are taken into account. One example is that the informal economy in a poor country such as e.g. Brazil seems likely to be a much larger fraction of the total output than in, say, a rich country such as Germany. Therefore, the purchasing power adjusted income data probably still overstate the true differences between countries. Furthermore, there will clearly be differences between the market basket of goods in an industrialized country such as Germany and a developing country such as Brazil.

Many variables applied in growth studies have statistical and conceptual problems. For example, human capital and education represent more than formal schooling (enrolment rates or years of schooling completed). The error of ignoring differences in the quality of schooling may be independent to that of measuring years of schooling or enrolment rates, but it is a component of the true measure of education. The relevant variable (quality) is omitted here and the error is not due to measurement errors in the variable[14]. Moreover, it must be mentioned that the secondary school enrolment rate is preferable to literacy and primary school enrolment rates because many countries have reached the upper boundary for the latter measures. Although, some data might not be more than informed guesswork, we believe that they are still sufficiently accurate to show the differences between geographical regions and the key changes over time periods.

4.1 The Dataset

The main dataset used is that of Summers and Heston (PWT55), and it is supplemented with data series from the World Bank's Social Indicators of Develop-

[14]Mankiw, Romer and Weil (1992) discusses problems with proxies of human capital in detail.

ment (1993), World Development Indicators (1993) and UNESCO Yearbooks. The data series in the dataset are described in appendix B. A logarithmic scale has been used to some of the series to accommodate extremities of data.

A country is included in the dataset applied in the empirical work as long as it had a population of at least one million in 1990 and data are available for that country for a large set of economic and social indicators. We exclude countries with a population of less than one million because the wealth of such countries is too easily affected by external factors. In 1990, 104 countries in the world fulfilled these criteria. The data is set up as a cross-section of time series that covers three periods. Averages[15] of data over time periods which I assumed to incorporate the same inter-period information are applied in the following order: before the first oil crises (denoted the 60s), between the period of the first oil crisis and the initialisation of the debt crises (70s) and finally, the period containing the foreign debt crises (80s). Thus, the first sub-period spans from 1965 to 1973, the second from 1974 to 1982 and the third from 1983 to 1990.

4.2 A brief outline of the dataset

This section gives a brief description of the data for the 104 countries included in the data sample. It cannot possibly be described as complete or definitive as a summary of growth and development issues. It should, however, be useful in bringing an important statistical dimension to the study of growth and, additionally, in adding colour to the forces which have formed the world in which we are living. The comparison will focus on per capita income growth and three of its most important determinants as implied by the extended Solow model[16].

[15]One reason for not taking averages over the entire period for each country for every variable is that it would eliminate the information contained in the sample about the effect of changing conditions on growth. For example, it would not explicitly take into account that, e.g. at beginning in 1974, productivity growth slowed down. The reason for not taking every year in the period from 1965 to 1990 is that the proxies for human capital are available only in four year intervals before 1980 for many countries.

[16]Often the same data can be used to present progress and human suffering. One important failing in data available is the lack of differentiation between gender, class, location income or ethnic groups. It should be remembered that the school enrolment rates, GDP and the like are averages of totals for the population as a whole and may conceal e.g wide intra-country variations.

4.2.1 Real GDP per capita

Real GDP is, despite its drawbacks, used as an indicator of economic well-being. A couple of these drawbacks are: The first point is that GDP is an average and does not reveal anything about income inequality; it also gives no information about relative numbers of people in poverty. A more egalitarian society with lower GDP per capita may have a smaller proportion of poor inhabitants than a more unequal society with higher GDP per capita. Second, market valuations also mean ignoring or under-valuing non-market items, including production for direct use by peasants or others as well as less tangible aspects of well-being, such as health and pollution, while assuming any increase in marketed production is a benefit. The GDP per head for developing and developed countries have increased in real terms over the last three decades (see Table II).

Table II. Summery statistics of 104 countries.

		1965	1990	
GDP per capita (int. prices)	avg	2,688	4,630	
	std	2,716	5,019	
	min	279	297	
	max	11,492	18,399	
		1965-73	*1974-82*	*1983-90*
Per capita GDP growth rate (%)	avg	2.8	1.1	0.8
(int. prices)	std	2.6	2.8	3.0
	min	(4.0)	(6.4)	(12.0)
	max	10.4	9.8	9.5
Private investment share in GDP (ln)	avg	2.6	2.7	2.6
	std	0.8	0.7	0.7
	min	0.4	0.4	0.4
	max	3.7	3.6	3.6
Primary school enrolment rate (%)	avg	70.4	82.0	86.1
	std	33.9	29.8	27.7
	min	4.5	13.6	12.0
	max	125.0	129.0	128.4
Secondary school enrolment rate (%)	avg	26.7	40.2	47.3
	std	24.0	28.6	30.4
	min	1.0	2.1	3.4
	max	89.0	94.6	105.7
Pupil-teacher ratio, secondary	avg	21.7	24.3	22.6
Fertility rate (births per women)	avg	5.3	4.8	4.4
	std	1.8	2.0	2.0
	min	1.9	1.5	1.4
	max	8.0	8.1	7.7
Population growth rate (%)	avg	2.2	2.2	2.1
	std	1.0	1.0	1.1
	min	(0.6)	(0.1)	(0.1)
	max	5.2	4.6	4.1
Prices of Investment goods	avg	91.1	104.9	85.6
Openness (%)	avg	52.3	66.0	63.8
Life expectancy at birth (years)	avg	55.2	58.8	62.1
	std	11.7	11.3	10.9
	min	34.0	37.4	40.7
	max	74.4	75.5	78.2
Infant mortality rate (per 1000 live births)	avg	97.5	84.6	64.6
	std	56.7	79.5	46.9
	min	11.8	7.8	5.2
	max	204.5	697.6	171.0
Urban population percentage of total	avg	39.1	43.8	48.3
	std	25.3	25.0	24.2
	min	3.2	4.6	6.7
	max	100.0	100.0	100.0

In 1990, the average GDP per capita was 72 percent higher than in 1965 when GDP is based on what a currency can buy locally. The poorest country in 1965 was Ethiopia with an output per capita valuing 279 dollars. It was also the poorest in 1990 and its GDP per capita was 297 dollars. That shows that income raised by 6.4 percent. The richest country in 1965 and 1990 was the U.S.A. and the level of real per capita GDP was 11,492 dollars in 1965 and 18,399 dollars in 1990. That is a 60 percent raise in output per head of population in the US for the 25 year period under study.

The data reveals that growth rates have been rather unstable across both time periods and regions. The average growth rate for the 104 countries ("World") was 2.8 percent before the oil price raise in 1973-74 and it declined to 1.1 percent in the inter the first oil crisis pre-debt crises period. After the initialisation of the debt crises, the growth rate dropped to 0.8 percent.

Both the richest and the poorest countries grew, but relative to the developed nations the developing countries have declined. The OECD countries did better than the average in all three epochs but they experienced a huge decline after the first oil-price raise. On the other hand, in the 80s they experienced a rise in growth that no other region did.

When looking at the figures, it was the Latin American region which was worst hit --in terms of growth slow down-- by the world shocks. Africa performed poorly both before and after the initialisation of the oil- and debt-crisis. Asia experienced the largest decline in growth rates of all regions in 1983-90 but also the smallest drop in the 1974-82 period. However, certain countries in East and South Asia are now following the earlier example of Japan, and beginning to 'cross the gap' that may allow them to approach the economic levels of the industrialized world.

4.2.2 Physical capital investment, human capital and demography

The first kind of investment we will consider is the share of physical capital investment in GDP which was fairly constant (13 to 16 per cent) over the three sub-periods for the 104 countries, although the cross-nation variation is large. For example, the difference in the investment share is a factor of 26 among Madagascar and Finland. The Asian investment share rose while the Latin American fell over the three sub-periods. The second kind of investment taking into account is in human capital and it is proxied by the gross secondary school enrolment rates; this rose dramatically. It rose steadily from 27 % in the first sub-period to 47 % in the third. This means that the flow of human capital increased and, in the 1960s, one out of four children of school age was enroled in secondary school; by the 1980s this figure has risen to one out of two. In Africa in particular a large increase occurred, although all regions improved in terms of education. Education is seen as an element vital for developing human potential. Gender-differentiated data reveal that females are generally disadvantaged in relation to boys in many countries. Female education has a direct impact on demographic variables such as fertility rates and infant rates. Female education is thus seen as a health issue, a means towards a lower population growth rate and towards achieving other goals as well as an end in itself.

Turning to the third type of investment, the demographic data reveal that the growth rate of population over the three time-periods was reasonably constant. In contrast, fertility has fallen over time in all the regions considered. The number of births per woman of childbearing age has fallen from nearly 5 in the 1960s to 4 in the 1980s. The variation in data is large and the maximum number of births in data is 8 (Kenya in the 60s) and the minimum is 1.4 (Italy in the 80s).

4.2.3 More social indicators of development

Social well-being, and its converse poverty, are multi-faceted: disease, illiteracy and isolation are interrelated and cannot be reduced to a single indicator. The rural populations are often the most disadvantaged because they have poor access to economic opportunities and social services. Although the number of urban poor is increasing, the relative size of the rural population may still be taken as an indicator of poverty. The figures show that the urban population has increased across time for all regions.

Turning to other indicators of development concerning the physical quality of life, life expectancy and infant can be considered. Both indicators have improved world wide since the 1960s, although the variation across countries is enormous. In the 1960s, a child at the age of one born in Sierra Leone could expect to live for 34 years. On the other hand, in the 1980s a child born in Hongkong could expect to live 78 years. In general, life expectancy has improved, but by 1990 life expectancy for 16 countries was still below 50 years. Death rates among children also tell us something about poverty. They reflect the wealth, schooling and living conditions of the parents. The number of infants who died before reaching one year of age has --world wide-- decreased 34 percent from the 60s to the 80s[17].

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[17]Democratization, human rights and other aspects of 'freedom' also seem important, but are not at this stage included in the analysis.

The three decades up to 1990 saw improvements in aspects of human development such as health and basic education. There was a decrease in disparities in infant , school enrolment and life expectancy, although many parts of the developing world still have much 'catching-up' to do to equal the standards of developed countries.

5. Results

As mentioned above, exogeneity is analyzed within a framework which consists of four endogenous variables: the real per capita GDP growth rate, the rate of enrolment in secondary schools, the share of physical capital investment in GDP and the fertility rate. A four dimensional unrestricted quadratic system is set up as a benchmark. The set of endogenous variables (y_t) are: g_t, $FERT_t$, $ENR2_t$ and I_t, where t indicates time period

$$y_t = Ay_{t-1} + Cz_t + \varepsilon_t \tag{8}$$

The vector of dependent variables are regressed on: 1) the history of the dependent variable (y_{t-1}): g_{t-1}, I_{t-1}, $ENR2_{t-1}$ and $FERT_{t-1}$ where t-1 indicates the period before t; and 2) a set of assumed exogenous variables (z_t): the relative price of investment (PI_t), GDP_t, the infant rate ($IMOR_t$), export plus import to nominal GDP ($OPEN_t$), the life expectancy ($LIFE_t$), pupil to teacher ratio ($P\text{-}T_t$) and urban population share (URB_t).

Furthermore, the possibility of quadratic relationships is allowed for. This is done by adding GDP_t squared (denoted by adding SQ to the abbreviation)[18]. The economic explanation for including the dependent variables from previous periods is that there might be costs of adjustment with the consequence that adjustments do not take place immediately. The residuals are assumed to be normally distributed with zero mean and constant covariances. The results of the regressions are presented in Appendix C.

[18]Results (which are not reported in this paper) show that the inclusion of I2SQ, enr22SQ and fert2SQ is not statistically significant in any single equation or in the system. The same holds for the government investment share in the GDP variable. Military expenditure, unlike that of education, health and infrastructure, is not 'wealth' producing, but it is part of government expenditure.

5.1 Results from the 80s

The set of endogenous variables (y_t) for the 80s is: g3, fert3, enr23 and I3, where 3 indicates that the variable is for the period 1983 to 1990. The regressors are the history of the dependent variables (g2, I2, ENR22, and FERT2, where 2 indicates the period 1974-1982) and the aforementioned exogenous variables.

The explanation for including the specific country dummies in the regression (see System 1 in Appendix C) is that the null of vector-normality and homoscedasticity was rejected when diagnostic tests were performed without dummies[19]. The different performances of these outlier countries -- compared to the international level revealed by data -- can perhaps be explained by: the introduction of different stabilization plans and, maybe, the overhanging debt in Bolivia (BOL) which led to a low investment performance, the war between Iran and Iraq (IRQ) led to a low growth performance. In contrast, the wages of the offshore workers in the OPEC countries which, is spent in the home country, Yemen (YEM), and the rise in the market price, and the discovery of diamonds in Botswana (BWA) promoted a fast growth conditional on the explanatory variables. Uganda (UGA) and Tanzania (TAN) had higher school enrolment rates than the international level revealed by data would suggest, while Angola (ANG) had lower.

On average, the correlation between the actual and fitted values, are around 97 per cent for FERT3, I3 and ENR23, and 83 per cent for g3 are high. It is noteworthy that the GDP squared is significant within the system. This is a sign of the possibility of non-linearities[20]. In particular, richer a country, the fewer children are born there, although only until a threshold income level is reached. Another feature is that in this system there is no sign of conditional convergence. Additionally, it can be seen that the correlation between the residuals of the equation for school enrolment and growth is low (0.07). This would indicate that enr23 could be weakly exogenous for the parameters of interest in the equation for growth in 1983-90. Formal tests for this feature were performed and the results are presented in Model 1.

The tests for weak exogeneity are performed by estimating and saving the residuals for each equation of the system. Moreover, one must impose restrictions and test if these are valid restrictions imposed on the system. If the restrictions imposed are not rejected, then the unlagged explanatory variable and

[19]The specific countries were uncovered by recursive estimation of the system of equations and graphic analysis.

[20]Data are ordered by income level in 1983.

the residuals from the respective equations of interest are inserted into the growth equation. If the estimated coefficient on the residuals is insignificant, then the null hypothesis, that the relating endogenous variable is weakly exogenous is not rejected. In this case, the marginal process can be left unmodelled. The residuals of the four equations in the system are called: VI3, Venr23, Vg3 and Vfert3[21], where e.g. VI3 denote the residuals from the equation of investment in the 80s. The restrictions imposed, when testing, are that the rate of school enrolment, investment and fertility in the 1970s did not affect the growth rate of the 80s.

Additionally, the restrictions that the contemporaneous infant rate, pupils to teacher ratio and the relative price of investment goods are of little importance for growth are imposed. These restrictions are not rejected.

The restricted reduced form (Model 1) shows that the parameters of Venr23, VI3 and Vfert3 are statistically insignificant in the growth equation. Thus, the null that school enrolment is weakly exogenous for growth is not rejected. This suggests that it is reasonable not to model fertility,[22] investment and enrolment when we study growth[23]. The results obtained when estimating the system showed that the rate of growth in the 1970s (g2) Granger caused enrolment in the 1980s (enr23). This implies that the secondary school enrolment rate is not strongly exogenous for economic growth. When growth rises, the level of education subsequently rises.

Surprisingly, the higher level of education in the 70s did not lead to a significantly higher growth in the 80s. This contrasts with the predictions from the single equation growth models, where the school enrolment rate was found to be an important growth promoting factor (Barro (1991), Mankiw, Romer and Weil (1992)) and also some endogenous growth models (see e.g. Lucas (1992)). In the former, higher schooling leads to a higher level of per capita income in the steady state and, subsequently, to higher growth rates on the transition path

[21]The system is re-estimated with the residuals added as an identity. Furthermore, enr23, I3 and fert3 enter as exogenous. Thus after this, a model is formulated and the explanatory variables from the system enter as explanatory variables in VI3, Venr23 and Vfert3.

[22]Verner (1993) show that the determinants of fertility and population growth are largely different. The school enrolment rate, initial income level, under five mortality rate, and a region dummy for Latin America explain 64 per cent of the variation in fertility, while only 30 per cent of the population growth rate is explained for the 1965 to 1985 period. Additionally, Verner (1994) shows that when modelling growth as a system of equations where the population growth rate is included instead of the fertility rate; the weak exogeneity of both investment and population growth can be rejected and, therefore, cannot be left unmodelled.

[23]It should be remembered that there is always a non zero probability of a type one error.

toward the steady state. In the latter, higher savings induce a permanently higher rate of growth. Could this difference be because enrolment in secondary school is not a good proxy for human capital?

Is it possible that the rate of fertility and the investment share in GDP are exogenous? Model 1 shows that VI3 is not significantly different from zero, which leads us to not reject the null of weak exogeneity. Additionally, the null of weak exogeneity can also not be rejected for the fertility rate. Thus, the hypothesis that the marginal process of both investment and fertility rate can be left unmodelled are not rejected, which is, to say the very least, rather surprising. In System 1, we observe that the parameter estimates on lagged growth are significantly different from zero in the investment and fertility equation. Therefore, growth in the 70s did Granger cause a higher investment share and a fall in the fertility rate.

Regressions (not reported) show that for the 1983-90 period:
(1) the hypothesis that school enrolment is weakly exogenous for the parameters of interest in the fertility and investment equations cannot be rejected, (2) the hypothesis that fertility rate is weakly exogenous for the parameters of interest in the school enrolment and investment equations cannot be rejected, (3) the hypothesis that investment rate is weakly exogenous for the parameters of interest in the school enrolment and fertility equations cannot be rejected, (4) the growth rate of the 1974 to 1982 period is *not* weakly exogenous for the parameters of interest in the other three equations; this means growth has to be modelled when studying fertility, investment and school enrolment.

Model 2 is the selected growth model. It shows that countries with a lower fertility rate in the 80s also had a higher output growth rate. This might indicate the possibility of an implicit decision of parents between having children or saving in other assets as an insurance for the future, as it is generally agreed upon that the capital markets in the developing countries are rather imperfect. Fertility generally falls as people move toward urban areas, as having many children there often leads to extra expenses (e.g. the cost of day care might not occur in the rural areas due to its not being provided and instead the presence of the family structure, where members help each other out). Additionally, the financial sector is more developed in the urban areas. Therefore, if children serve as a form of pension in the rural areas --due to the missing market-- they are not as needed in the urban areas as other financial institutions exist.

Higher investment rates in the 80s tended to lead to higher a growth in the 80s, but it is noteworthy that it is only marginally significant different from zero. This finding seems odd because, if a country invests a lot and does not grow, there must exist a persistent inefficiency. Additionally, it can be rejected that the coefficient on the initial income level is zero. That is, poor countries are capable of catching up to their steady states. This is in line with what the *multi-sector* endogenous growth models (see e.g. Barro and Sala-i-Martin; 1994) and the Solow (1956,1957) model predict. On the contrary the one sector endogenous growth models á la Romer (1986) are rejected by this finding because there seem to exist decreasing marginal returns to investment cross countries and, therefore, low income countries grow faster than high income countries conditional on their steady states.

Model 3 includes region dummies for Asia (AS), Latin America (LA) and Africa (AF). The result is that the Latin American countries have grown significantly less than the international level revealed by the data when accounting for the investment share in GDP, initial income level and the fertility rate. The significant region dummy indicates that there are regularities for which the model cannot account. Therefore, additional studies are needed where the outstanding foreign debt, and the general lack of political stability, among other factors, should be included -- at least as a starting point.

The African and Asian countries *have not* experienced a significantly lower or higher income growth rate in the 80s. The former cross country studies (e.g. Barro (1991)) were not capable of explaining all growth experience of the African countries. This model, however, is. One reason for this is that in this model the large number of children which are born in these countries are being controlled for.

The results of the empirical studies for the 80s can be summarised as follows: First, the hypothesis that human capital, investment, and fertility are weakly exogenous for the parameters of interest in the extended Solow growth model in the 1983 to 1990 period cannot be rejected. Second, the growth between the first oil crisis and the initialisation of the debt crisis caused, in the sense of Granger, school enrolment, investment, and fertility. When growth rises, the level of, say, education subsequently also rises. Third, surprisingly, more education did not lead to a statistically significantly higher growth in the 1980s as no direct effect from the school enrolment rate to growth is revealed, in contrast there is significant coefficient from fertility and investment to growth. Fourth, poor countries are apparently capable of catching up to their steady states. Fifth, the negative partial correlation between fertility and countries growth captured the low growth performance of the African countries, but not of the Latin American. This means that regularities are still missing in the model for these countries. Additionally, it should be noted that there is no sign of misspecification (non-normality, cross-country autocorrelation, heteroscedasticity, wrong functional form) and parameter non-constancy in the model when the data for 100 countries are applied. Are the same results obtained for the period running from 1974 to 1982? This question will be studied in the following section, but it can already be claimed that in general the answer is no.

5.2 Results from the 70s

The unrestricted reduced form for the period between the first oil price rise and the beginning of the debt crisis will now be considered. It is modelled in the same way as the unrestricted reduced form from the 80s[24]. The main difference is that the growth rate, investment share, fertility and secondary school enrolment from the 1965 to 1973 period are included as explanatory variables (denoted g1, I1, ENR21 and FERT1). The set of assumed exogenous variables are PI2, GDP2, IMOR2, OPEN2, LIFE2, P-T2 and URB2. The country dummies which are included are different. Somalia (SOM), Jordan (JOR), Congo (COG) and Trinidad & Tobago (T&T) all experienced a higher growth rate than the international level revealed by the data. Mauritius (MAU) has both a higher physical capital investment and secondary school enrolment rate. Togo (TOG) has higher school enrolment while Rwanda (RWA) has less school enrolment. When including the aforementioned country dummies in the regression, the underlying assumptions, normally distributed, homoscedastic, and with no serial correlation when ordered by initial income level in the residuals, are not rejected. The results are presented in System 2.

The correlation between the actual and the fitted values is on average 0.94 for the three types of investment: ENR22, FERT2 and I2. This means that a very large part of the variation in these series is explained by the included regressors. In the growth equation, 73 per cent of the variation is explained. The explanatory variables which turned out to be statistically significant in the system are ENR21, LIFE2, FERT1, PI2, g1 and I1. Surprisingly, GDP in 1974 is statistically insignificant in both the system and in each single equation. The same is true for the quadratic term (GDP2SQ), but imposing the restriction, which is zero, means that significant negative coefficient on GDP in 1974 so economic catch up is present in the system. The residuals of the four equations in the system are named: VI2, Venr22, Vg2 and Vfert2, where e.g. VI2 denote the residuals from the equation of investment in the 70s.

The correlation of residuals from the FERT2 equation (VFERT2) and g2 equation (Vg2) is only 0.08. This indicates that FERT2 could be weakly

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[24]Data are ordered by income level in 1974.

exogenous for the parameters of interest in the growth equation. The results of formally testing this feature are displayed in Model 4. The estimation technique is Full Information Maximum Likelihood (FIML). The coefficient on VFERT2 is statistically insignificant and, therefore, the null hypothesis of weak exogeneity cannot be rejected. This could suggest that fertility does not have to be modelled when studying the determinants of economic growth conditional on the included regressors. That is the marginal process contain no extra information which is not already in the model. Furthermore, it cannot be rejected that fertility is weakly exogenous for investment and human capital either. This is rather astonishing. In each case the zero-restrictions imposed, when testing for weak exogeneity, are that ENR21, FERT1 and I1 --that is secondary school enrolment, investment and fertility in the 60-- do not affect the dependent variables in the 70s. Additionally, the RWA, TOG and MAU dummies are removed.

The Likelihood Ratio test suggests that the overidentifying restrictions cannot be rejected. The restricted reduced form (Model 4) shows that the parameters of VENR2 and VFERT2 (the residuals from the fertility and enrolment equations from System 2) are not significantly different from zero in the growth equation. This means that school enrolment can be left unmodelled when studying growth. Contrarily, *physical capital investment* does have to be modelled as the hypothesis that the coefficient on VI2 is zero can be rejected --this seems sensible from an economic point of view too. Therefore, we have to model both investment and growth jointly as we are aiming for unbiased estimates of the parameters. Estimating this model by FIML reveals that enrolment is again weakly exogenous for the parameters of interest in the growth equation but not for the parameters of interest in the investment equation[25] (see Model 5). Therefore, the final model which we have to consider when analyzing growth in the 70s is a system of three equations: growth, investment and school enrolment (Model 6)[26]. Again, it cannot be rejected that fertility is weakly exogenous for the parameters of interest in the three equations under study. Model 6 also shows that growth in the 60s is an important determinant of growth in the 70s.

Additionally, it is influential in explaining the investment share in GDP and the secondary school enrolment rate. That is, the fast growers of the pre-oil price

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[25]Fertility, school enrolment, RWA, TOG and MAU are imposed zero-restrictions in the growth equation, T&T, COG and Somalia in the investment equation. These restrictions are not rejected by the LR test of over-identifying restrictions.

[26]The zero restrictions imposed on the unrestricted reduced form are that FERT1 is zero in all three equations. Additionally, RWA, TOG, and MAU are zero in the growth equation, T&T, COG, JOR and SOM are zero in the investment equation and T&T, JOR and SOM are zero in the enrolment equation.

rise could expect to grow fast after the oil crisis started. This is in line with what we saw in the simple statistics from section 4. The Asian region did not experience a growth slow down in the 70s.

Model 7 presents a more parsimonious specification of Model 6. Fertility is also in the 70s an influential factor in explaining the growth performance of countries. Countries with a high fertility rate grew less than countries with a low fertility rate. This could indicate that when GDP has to be divided among a large number of people where many are currently unproductive retard growth because the children born in the 70s are not capable of contributing to the GDP in that period. This could explain why fertility is negatively correlated with economic growth. Enrolment is also a highly significant determinant of growth in the 70s. The countries which invested a lot in their citizens in the 60s tended to growth faster in the 70s. This result is in line with the studies mentioned in section 2.

It should be noted that ENR21 is also an important factor in explaining secondary school enrolment in the 70s. The higher the level of children who were educated in the 60s led to a higher level of education in the country in the 70s. Thus, that secondary school enrolment increased --in both the rich and the poor countries --is promising for the reduction of fertility. The more education a parent has, the higher is the opportunity cost of having an extra child in terms of forgone wages. It is clear, that what matters is not having an extra child but rearing a child because it could be seen as time consuming. The circle does not finish here. As mentioned above, a fall in fertility leads to higher growth so there is both a direct and an indirect effect of education.

Education, on the other hand, did not statistically significantly directly influence investment -- possibly it did so indirectly if it is the case that education affected the growth rate of the 60s. This result seems odd mainly because machines used in industries etc. become increasingly advanced and people who work with them need to be more and more specialised. It is often seen that sufficiently low wages are insufficient to attract computer-age industries. Very large investment in modern machinery and a skilled labour force are needed and one way of obtaining these by education.

The initial level of income is highly significant in explaining the economic growth of the 70s. Conditional on FERT2, g1, ENR21, and PI2 the poor countries grow faster than the rich countries. Additionally, the GDP in 1974 is also important in explaining the variation of investment across countries. The countries which initially had a high income level invested more than the poorer countries. This indicates a divergence in the investment share among the developed and the developing countries.

Surprisingly, the investment share in the 60s does not seem statistically important in explaining the growth of the 70s. On the other hand, a high relative price of investment goods lowers the growth rate and the investment share.

The hypothesis that when more people live in urban areas an equal number of children in the age group goes to school is only marginally rejected. The regression shows that countries which have a low rural population in the 70s obtained a more educated population than the countries with a high percentage of people living in the countryside.

Model 7 shows that if a country outperforms in terms of growth, it does not necessarily have to do better than the international level revealed by data in terms of investment and education. T&T, JOR and SOM did perform better than the average in terms of economic growth, but not in terms of investment in a broad sense when their starting point in terms of income, their fertility rate, education level in the 60s etc. are controlled for. When the region dummies for Africa, Asia and Latin America are included in each of the three equations, the outcome is (not reported) that Africa did not perform statistically differently to the international level in either growth, investment or human capital in the 70s when conditioning on the included variables. Asia did only marginally better than the international level in terms of investment and Latin America outperformed also only marginally in terms of secondary school enrolment. As a final remark it should be noticed that the underlying assumptions of the residuals --vector normality, vector homoscedasticity and no vector serial correlation when ordered by initial income level were not rejected.

The results of the empirical studies for the 70s can be summarised as follows: First, the hypothesis that human capital, investment, and fertility are weakly exogenous for the parameters of interest in the extended Solow growth model in the 1983 to 1990 period can be rejected only for investment. However, secondary school enrolment is not weakly exogenous for the parameters of interest in the investment equation. Therefore, the three equations have to be jointly modelled. Second, growth before the first oil price rise caused, in the sense of Granger, school enrolment, investment, and fertility. When growth rises, the level of, say, education subsequently also rises. Additionally, more education in the 60s led to a significantly higher growth in the 1970s. Third, a direct effect from fertility to growth is revealed. Fourth, poor countries are capable of catching up with the rich countries. Fifth, no significant partial correlation between growth, investment and education and the three regions Africa, Latin America, and Asia are shown when modelling a simultaneous equation model. This means, that no statistically significant regularities are missing in the model for these regions. Additionally, it should be noted that there is no sign of misspecification such as vector non-normality, vector serial correlation when ordered by initial income level and vector heteroscedasticity in the model when data for more than 100 countries are applied.

5.3 Panel analysis

Let us now consider the three time periods together. That is done by applying the whole panel dataset. That gives the possibility of studying economic development at a more disaggregate level than the traditional cross-section studies. The pooled dataset allows one to analyze the possibility that different growth patterns exist across different time periods, i.e. a heterogenous pattern of economic development is present and for our purpose especially the period of the oil-crisis and the following period: the initialisation of the debt crises. Therefore, we pool the data used in the former analysis[27]. Thus, the series are made up by two data points for each of the 104 countries and, therefore, the total number of data points is 208.

We use the same explanatory variables as above and some supplementary variables which could uncover possible parameter non-constancies across time. The additional variables are: 1) a time dummy (DUM) which is able to catch if a shift exist across time periods, i.e. a fixed effect[28]; 2) the shift dummy (DUM) multiplied by each of the explanatory variables and these new variables can catch possible random effects; i.e. they grasp possible parameter non-constancies and dissimilar importance of the explanatory variables across the different time periods[29]; 3) country dummies which can take to forms: a pure impulse country dummy[30] which basically eliminates the data point (this is the type of country dummy employed above). The second type is a panel country dummy[31].

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[27]For example, the growth series in constructed by sorting the data by income in the initial year and, subsequently, the pooling is done by stacking the series from the 80s and the 70s. The variable lagged growth (glag) is constructed by stacking the series from the 70s followed by the series from the 60s.

[28]The step dummy (DUM) takes the value zero from the first to data point number 104, and the value 1 from the data point number 105 to 208.

[29]For example, DGDP is constructed by multiplying DUM by GDP and captures the effect of changes in income level on economic growth.

[30]The impulse country dummy for a country takes the value 1 for a particular country in a particular period. Therefore, the series takes the value zero for 203 data points.

[31]The panel country dummy takes the value one for a particulary country in both periods.

If the estimated parameters are equal across time periods the underlying model which generated data could be the same across decades for all the countries included in the study. That is to say, if the hypothesis that no differences exist across time periods is not rejected then it is appropriate to carry out panel analysis like done in e.g. Barro and Lee (1993). It is not obvious that the analysis gives this result, especially, because many countries have had very different growth experiences in the periods under study. To summarise, in the following we will study the appropriateness of aggregating data across time periods -- the 70s and the 80s -- before applying an identical growth model across time and countries.

The panel data analysis indicates that the underlying model under the oil crises and after the initialization of the debt crises is significantly different. Different explanatory variables have different influence on the determination of growth in the 70s and the 80s. That is to say that the hypothesis, the data for the 70s and 80s can be pooled, is rejected. Thus, performing analysis on growth by pooled data would be a mistake. The regressions performed show that the misspecifications such as vector non-normality and vector spatial correlation cannot be removed by introducing a reasonable amount of country dummies of either of the aforementioned type in the simultaneous system of equations. We would have to introduce so many country dummies (impulse or panel) that only few degrees of freedom are left. The t-statistics shows that the coefficient estimates are very different across the 70s and the 80s[32].

A formal test of the null hypothesis that the 70s are like the 80s can be performed by a Likelihood Ratio test. Two models are estimated: One includes all the explanatory variables included in System 1 and the shift dummy and is, therefore, the restricted model. The log-likelihood value from this regression is 918. The other model includes all the variables from System 1 and, additionally, the shift dummy (DUM) multiplied by all the aforementioned explanatory variables. The second model, the unrestricted model, includes 13 more variables in each of the four equations than the restricted model and the log-likelihood value from estimating this system is 986. The likelihood ratio test (LR) is:

$$LR(48) = 2*(986 - 918) = 136$$

[32]The author is fully aware that the coefficients estimates are neither efficient or consistent when the model is misspecified, but the t-statistics are so far apart fort the two decades that with a bite of prudence one can interpret the direction of the coefficients.

This is far above the critical value, for Chi(48), which is around 67 using a 95 per cent significance level, hence, the null hypothesis of constant parameters across sub periods can be rejected. The hypothesis that the 70s is equal to the 80s are, therefore, rejected.

This result shows that it would be inappropriate to impose the assumption the coefficients of the explanatory variables and variance and covariances are equal across decades. Imposing this false assumption could create outliers. The result of the panel analysis is in line with the different results obtained in the separate analysis of the 70s and the 80s and with Easterly et al. (1993) who found that economic growth across countries in the last decades is determined by different variables. The test statistics and the LR test show that the underlying assumptions in Barro and Lee (1993) among others of parameter constancy and normal distributed residuals do, in general, not hold.

6. Conclusions

The ideal way to distinguish between the old versus the new growth models would be through empirical investigations. However, to date these studies have not been performed very successfully in the literature, if they have ever really been tried. The aim of this paper was more modest than this. Evidence for the explanatory variables not being weakly exogenous was discussed and, additionally, some emphasis was placed on the discussion of economic convergence. This analysis further permits a comparison of the results of the exogeneity analysis for the 70s and the 80s and examines if it is the same factors that determine growth in the two periods under consideration.

The results of the empirical studies for the 70s and 80s will now be summarised. Before that is done it should be noted that there are no signs of misspecification such as vector: non-normality, serial correlation when ordered by initial income level and heteroscedasticity in the model when data for around 100 countries are applied. First, the hypothesis that human capital, investment, and fertility are weakly exogenous for the parameters of interest in the extended Solow growth model in the 1983 to 1990 period cannot be rejected. However, the aforementioned hypothesis can be rejected for the 1974 to 1982 period, concerning investment share in GDP. This means that the marginal distribution of the conditioning variable --investment-- has to be modelled. Second, growth Granger caused school enrolment, investment, and fertility. When growth rises, the level of, say, education subsequently also rises. Surprisingly, more education did not lead to significantly higher growth in the 1980s, although it did in the 70s. Third, poor countries are capable of catching up, i.e. β-non-convergence can be rejected for either of the two sub periods. Fourth, an important result from this study is that fertility is strongly negatively correlated with economic growth. That is, the lower the fertility of a woman in her fertile age in a country, the more that particular country will grow. Fifth, the negative partial correlation between fertility and growth indicates that the fertility rate is an important factor in explaining the variances in the growth rate. It seems reasonable that fertility captures the low growth performance of the African countries in the 70s and the 80s as the African continent dummy is statistically insignificant. However, it does not capture the Latin American performance in the 80s, which means that regularities are still missing in the model for Latin America. Sixth, the panel data analysis reveals that the same model of economic growth is not valid for the different time periods under study. Therefore, it is not correct to pool data as parameters are not constant across decades.

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"WORLD"		REGIONS			
		"AFRICA"	"ASIA"	"LATIN AMERICA	"OECD"
ALGERIA	MADAGAS.	ALGERIA	BANGLA.	ARGENTI.	AUSTRA.
ANGOLA	MALAWI	ANGOLA	HONG K.	BOLIVIA	AUSTRI.
ARGENTINA	MALAYSIA	BENIN	INDIA	BRAZIL	BELGI.
AUSTRALIA	MALI	BOTSWA.	INDONES.	CHILE	CANADA
AUSTRIA	MAURITAN.	BURKI.F.	IRAN	COLOMB.	DENMA.
BANGLADE.	MAURITIUS	CAMER.	IRAQ	COSTA R.	FINLA.
BELGIUM	MEXICO	C.AFR.R.	ISRAEL	DOMIN.R	FRANCE
BENIN	MOROCCO	CHAD	JORDAN	ECUADO.	GERMA.
BOLIVIA	MOZAMBI.	CONGO	KOREA R.	EL SALV.	GREECE
BOTSWANA	MYANMAR	CO. DIVO.	MALAYS.	GUATEM.	IRELAN
BRAZIL	NAMIBIA	EGYPT	MYANM.	HAITI	ITALY
URKINA FA.	NEPAL	ETHIOPIA	NEPAL	HONDUR.	JAPAN
CAMEROON	NETHERL.	GABON	PAKISTA.	JAMAICA	NETHER.
CANADA	NEW ZEAL.	GHANA	PAPUA G.	MEXICO	NEW ZE.
CENT.AFR	NICARAGUA	GUINEA	PHILIPPI.	NICARAG.	NORWA.
CHAD	NIGER	KENYA	SINGAPO.	PANAMA	PORTU.
CHILE	NIGERIA	LESOTHO	SRI LAN.	PARAGU.	SPAIN
COLOMBIA	NORWAY	LIBERIA	SYRIA	PERU	SWEDEN
CONGO	PAKISTAN	MADAGA.	THAILAN.	PUERT.R.	SWITZE.
COSTA RICA	PANAMA	MALAWI	YEMEN	TRINI.&T.	TURKEY
COTE DIVOI.	PAP.N.GUI.	MALI		URUGU.	U K
DENMARK	PARAGUAY	MAURIT.		VENEZU.	U S A
DOMINIC.R.	PERU	MAURITI.			
ECUADOR	PHILIPPINES	MOROCC.			
EGYPT	PORTUGAL	MOZAMB.			
EL SALVAD.	PUERTO	NAMIBIA			
ETHIOPIA	RICO	NIGER			
FINLAND	RWANDA	NIGERIA			
FRANCE	SENEGAL	RWANDA			
GABON	SIERRA LEO.	SENEGAL			
GERMAN.W	SINGAPORE	SIER.LEO.			
GHANA	SOMALIA	SOMALIA			
GREECE	SOU.AFRICA	SOU.AFR.			
GUATEMA.	SPAIN	TANZANI.			
GUINEA	SRI LANKA	TOGO			
HAITI	SWEDEN	TUNISIA			
HONDURAS	SWITZERL.	UGANDA			
HONG KONG	SYRIA	ZAIRE			
INDIA	TANZANIA	ZAMBIA			
INDONESIA	THAILAND	ZIMBAB.			
IRAN	TOGO				
IRAQ	TRINID&TO.				
IRELAND	TUNISIA				
ISRAEL	TURKEY				
ITALY	UGANDA				
JAMAICA	U K				
JAPAN	U S A				
JORDAN	URUGUAY				
KENYA	VENEZUELA				
	YEMEN				
	ZAIRE				
	ZAMBIA				
	ZIMBABWE				

The data variables used in the empirical studies are described in this appendix. The periods used are: 1965-73, 1974-82, 1983-90 and the variable has a number attached referring the mentioned periods (1,2,3). for example FET is the fertility in the third period: 1983-90. Initial means it is the value of the variable in the first year of the data period.

FERT Average total fertility rate where total fertility rate is the number of births per woman of childbearing age, which are the years from 15 to 49. The total fertility rate represents the number of children that would be born to a women if she were to live to the end of her child bearing age and bear children at each age in accordance with prevailing age specific fertility rates.

IMOR Infant mortality rate. Number of infants who died before reaching one years of age, per thousand live births.

POPG The average population growth rate. Numbers are mid year (Summer and Heston use end year). Refugees not permanently settled in the country of acyl are generally considered to be part of the population of their origin.

ENR1 The avg gross enrolment in primary school (log), where gross enrolment in primary school is the percentage of the school age group. Many countries consider primary school age to be 6 to 11 years. other do not. For some countries with universal primary education, the gross enrolment ratios may exceed 100% because some pupils are younger or older than the countries standard primary school age.

ENR2 The avg gross enrolment in secondary school ratio (log), where gross enrolment in secondary school ratio (percentage of the school age group, 12 to 17 years old). It is calculated in the same manner as primary school enrolment. Late entry of mature student etc can influence this ratio.

P-T Pupil-teacher ratio.

URB The average urban population, where urban population is calculated as a percentage of total population. The estimates in this sample are based on different national definitions of what is urban, therefore cross-country comparison should be made with caution.

LIFE The life expectancy at birth, total number of years.

I The avg share of real private investment in real GDP for the period (log).

GDP The real Gross Domestic Product, GDP, per capita in 1985 international prices, and it is calculated by a chain index (log). (Initial GDP).

G The annual per capita real GDP growth rate G is calculated from GDP as: $G=1/T(\ln GDP_{\text{final year}} - \ln GDP_{\text{initial year}})$ where T is the number of years (8,8,7).

PI The average price level of investment relative to the corresponding price in the US for the period, calculated as purchasing power parity relative to the US dollar divided by the exchange rate relative to the US dollar.

OPEN Openness. Export plus Import to GDP ratio.

System 1

Estimating the unrestricted reduced form by OLS. Sample is: 1 to 104

URF Equation for g3

Variable	*Coefficient*	*Std.Error*	*t-value*	*t-prob*
PI3	-8.82E-05	7.63E-05	-1.156	0.2510
OPEN3	5.15E-05	4.96E-05	1.039	0.3019
GDP3	-0.03327	0.032516	-1.023	0.3092
enr22	-0.00327	0.004694	-0.696	0.4886
g2	0.18933	0.080696	2.346	0.0213
LIFE3	0.000633	0.000725	0.873	0.3854
IMOR3	-8.68E-05	0.000159	-0.547	0.5856
fert2	-0.0113	0.002467	-4.581	0
I2	-0.00429	0.005006	-0.858	0.3936
URB3	-0.00023	0.00016	-1.439	0.1538
P-T3	0.000263	0.001738	0.151	0.8802
GDP3sq	0.001443	0.002115	0.682	0.4970
TZA	0.004297	0.019879	0.216	0.8294
IRQ	-0.08286	0.020056	-4.132	0.0001
BOL	0.006787	0.019141	0.355	0.7238
BWA	0.090349	0.020145	4.485	0
YEM	0.084117	0.01929	4.361	0
AGO	0.039502	0.021368	1.849	0.0680
UGA	0.071477	0.019493	3.667	0.0004
Constant	0.23146	0.13452	1.721	0.0890
$\sigma = 0.0185$	RSS = 0.0288			

URF Equation for I3

Variable	*Coefficient*	*Std.Error*	*t-value*	*t-prob*
PI3	-0.00311	0.000994	-3.133	0.0024
OPEN3	-9.26E-05	0.000646	-0.143	0.8863
GDP3	-0.48263	0.42343	-1.14	0.2576
enr22	0.019944	0.061127	0.326	0.7450
g2	2.3077	1.0508	2.196	0.0308
LIFE3	-0.00108	0.009442	-0.114	0.9092
IMOR3	0.000215	0.002064	0.104	0.9172
fert2	-0.05918	0.032123	-1.842	0.0690
I2	0.67725	0.065189	10.389	0
URB3	-0.00347	0.002078	-1.67	0.0986
P-T3	-0.02472	0.022627	-1.093	0.2777
GDP3sq	0.037549	0.027543	1.363	0.1764
IRQ	0.7479	0.26117	2.864	0.0053
TZA	0.054933	0.25886	0.212	0.8325
BOL	-0.94388	0.24925	-3.787	0.0003
BWA	-0.14621	0.26232	-0.557	0.5788
YEM	-0.35003	0.2512	-1.393	0.1672
AGO	0.35756	0.27826	1.285	0.2023
UGA	-0.21554	0.25384	-0.849	0.3982
Constant	2.9134	1.7517	1.663	0.1000
$\sigma = 0.2410$	RSS = 4.8980			

SYSTEM 1 cont.

URF Equation for enr23

Variable	*Coefficient*	*Std.Error*	*t-value*	*t-prob*
PI3	0.001271	0.000724	1.754	0.0831
OPEN3	-0.00077	0.000471	-1.637	0.1054
GDP3	0.87201	0.30856	2.826	0.0059
enr22	0.7656	0.044544	17.187	0
g2	2.1742	0.76575	2.839	0.0057
LIFE3	-0.00365	0.00688	-0.531	0.5970
IMOR3	-0.00205	0.001504	-1.363	0.1766
fert2	-0.00668	0.023409	-0.285	0.7762
I2	-0.02692	0.047505	-0.567	0.5724
URB3	0.001872	0.001514	1.236	0.2199
P-T3	0.028427	0.016488	1.724	0.0884
GDP3sq	-0.0532	0.020071	-2.651	0.0096
IRQ	-0.0459	0.19032	-0.241	0.8100
BOL	-0.07365	0.18163	-0.405	0.6862
TZA	1.1631	0.18864	6.166	0
BWA	0.2675	0.19116	1.399	0.1654
YEM	-0.00578	0.18305	-0.032	0.9749
AGO	-0.44341	0.20277	-2.187	0.0315
UGA	0.50134	0.18498	2.71	0.0081
Constant	-2.3145	1.2765	-1.813	0.0734
$\sigma = 0.1760$	RSS = 2.6014			

URF Equation for fert3

Variable	*Coefficient*	*Std.Error*	*t-value*	*t-prob*
PI3	0.001384	0.001242	1.114	0.2685
OPEN3	0.00166	0.000807	2.058	0.0427
GDP3	-2.6571	0.52906	-5.022	0
enr22	0.069627	0.076377	0.912	0.3646
g2	-3.844	1.313	-2.928	0.0044
LIFE3	-0.03179	0.011797	-2.695	0.0085
IMOR3	0.00497	0.002579	1.927	0.0574
fert2	0.89301	0.040137	22.249	0
I2	0.11912	0.081453	1.462	0.1474
URB3	0.000364	0.002597	0.14	0.8888
P-T3	-0.01373	0.028271	-0.486	0.6284
GDP3sq	0.18176	0.034415	5.282	0
IRQ	0.010581	0.32632	0.032	0.9742
BOL	-0.49217	0.31143	-1.58	0.1178
BWA	-0.07984	0.32776	-0.244	0.8081
TZA	-0.47142	0.32344	-1.458	0.1487
YEM	0.44111	0.31386	1.405	0.1636
AGO	-0.54936	0.34767	-1.58	0.1178
UGA	0.28662	0.31717	0.904	0.3687
Constant	10.508	2.1887	4.801	0
$\sigma = 0.3017$	RSS = 7.6479			

Test System 1

- correlation of URF residuals

	g3	I3	enr23	fert3
g3	1.000			
I3	0.1113	1.000		
enr23	-0.0665	0.0849	1.000	
fert3	-0.2388	0.0869	-0.0707	1.000

- standard deviations of URF residuals

g3	I3	enr23	fert3
0.01855	0.2415	0.1760	0.3017

- loglik = 917.84838 R^2(LR) = 0.999858 R^2(LM) = 0.811859

- F-test against unrestricted regressors, F(76, 321) = 35.903 [0.0000]

- F-tests on retained regressors, F(4, 81)

- correlation of actual and fitted

g3	I3	enr23	fert3
0.8331	0.9516	0.9822	0.9906

- **Diagnostic tests**

g3	: AR 1- 2F(2, 82)	= 0.2609 [0.7710]
I3	: AR 1- 2F(2, 82)	= 0.8153 [0.4460]
enr23	: AR 1- 2F(2, 82)	= 2.9584 [0.0575]
fert3	: AR 1- 2F(2, 82)	= 1.0488 [0.3550]
g3	: Normality $Chi^2(2)$	= 4.4277 [0.1093]
I3	: Normality $Chi^2(2)$	= 2.4750 [0.2901]
enr23	: Normality $Chi^2(2)$	= 1.8617 [0.3942]
fert3	: Normality $Chi^2(2)$	= 1.8805 [0.3905]
g3	: Xi^2 F(31, 52)	= 0.3613 [0.9984]
I3	: Xi^2 F(31, 52)	= 1.1065 [0.3662]
enr23	: Xi^2 F(31, 52)	= 0.8150 [0.7259]
fert3	: Xi^2 F(31, 52)	= 1.0299 [0.4529]
Vector AR 1-2 F(32,270)		= 0.8628 [0.6831]
Vector normality $Chi^2(8)$		= 9.8364 [0.2767]
Vector Xi^2 F(300,445)		= 1.0218 [0.4164]

System 2

Estimating the unrestricted reduced form by OLS. Sample is: 1 to 104

URF Equation for g2

Variable	*Coefficient*	*Std.Error*	*t-value*	*t-prob*
Constant	0.30098	0.16357	1.84	0.0693
PI2	-0.00016	5.15E-05	-3.199	0.0019
OPEN2	6.63E-05	5.68E-05	1.167	0.2464
GDP2	-0.06954	0.045264	-1.536	0.1282
ENR21	0.006709	0.005065	1.325	0.1889
g1	0.38951	0.11437	3.406	0.0010
LIFE2	0.001307	0.000626	2.088	0.0398
IMORT2	-2.79E-06	3.86E-05	-0.072	0.9425
FERT1	-0.00142	0.00272	-0.521	0.6039
I1	-0.00994	0.005416	-1.835	0.0701
URB2	9.89E-05	0.000192	0.515	0.6081
GDPSQ	0.002981	0.002954	1.009	0.3160
LP-T2	-0.00022	0.002026	-0.11	0.9129
T&T	0.042389	0.022753	1.863	0.0660
COG	0.057478	0.023047	2.494	0.0146
JOR	0.085246	0.024244	3.516	0.0007
SOM	0.056598	0.022304	2.538	0.0130
RWA	0.00399	0.024578	0.162	0.8714
TOG	-0.01178	0.022444	-0.525	0.6010
MAU	0.00353	0.023674	0.149	0.8818
σ = 0.0217	RSS= 0.0394			

URF Equation for I2

Variable	*Coefficient*	*Std.Error*	*t-value*	*t-prob*
Constant	0.87852	2.1768	0.404	0.6875
PI2	-0.00281	0.000685	-4.096	0.0001
OPEN2	-0.00049	0.000756	-0.644	0.5216
GDP2	-0.17199	0.60238	-0.286	0.7760
ENR21	-0.06268	0.0674	-0.93	0.3551
g1	5.4132	1.522	3.557	0.0006
LIFE2	0.011898	0.008326	1.429	0.1567
IMORT2	0.000384	0.000513	0.748	0.4568
FERT1	0.053471	0.036201	1.477	0.1434
I1	0.4923	0.072076	6.83	0
URB2	0.0022	0.002556	0.861	0.3919
GDPSQ	0.016868	0.039317	0.429	0.6690
LP-T2	0.027525	0.026958	1.021	0.3102
T&T	0.13562	0.3028	0.448	0.6554
COG	0.012915	0.30671	0.042	0.9665
JOR	0.56246	0.32264	1.743	0.0849
SOM	0.32704	0.29682	1.102	0.2737
RWA	-0.6278	0.32708	-1.919	0.0583
TOG	0.539	0.29869	1.805	0.0747
MAU	1.0336	0.31506	3.281	0.0015
σ = 0.2884	RSS= 6.987			

System 2 cont.

URF Equation for ENR2

Variable	*Coefficient*	*Std.Error*	*t-value*	*t-prob*
Constant	-1.5403	1.8005	-0.855	0.3947
PI2	0.000337	0.000567	0.595	0.5538
OPEN2	-0.00106	0.000625	-1.69	0.0947
GDP2	0.57144	0.49823	1.147	0.2547
ENR21	0.70387	0.055746	12.626	0
g1	2.8328	1.2589	2.25	0.0270
LIFE2	0.009432	0.006887	1.37	0.1745
IMORT2	0.000469	0.000425	1.104	0.2729
FERT1	0.018089	0.029942	0.604	0.5474
I1	-0.01037	0.059614	-0.174	0.8623
URB2	0.004278	0.002114	2.023	0.0462
GDPSQ	-0.0402	0.032519	-1.236	0.2198
LP-T2	0.004509	0.022297	0.202	0.8402
T&T	0.23787	0.25045	0.95	0.3449
COG	0.55033	0.25368	2.169	0.0329
JOR	0.39868	0.26686	1.494	0.1389
SOM	0.044375	0.2455	0.181	0.8570
RWA	-1.0569	0.27053	-3.907	0.0002
TOG	0.88667	0.24705	3.589	0.0006
MAU	0.69204	0.26058	2.656	0.0095
$\sigma = 0.2385$	RSS =4.78			

URF Equation for FERT2

Variable	*Coefficient*	*Std.Error*	*t-value*	*t-prob*
Constant	5.8818	2.9308	2.007	0.048
PI2	0.002112	0.000923	2.289	0.0246
OPEN2	-0.00107	0.001018	-1.05	0.2968
GDP2	-0.95614	0.81103	-1.179	0.2418
ENR21	-0.16924	0.090745	-1.865	0.0657
g1	-1.0073	2.0492	-0.492	0.6243
LIFE2	-0.03832	0.01121	-3.418	0.0010
IMORT2	0.000552	0.000691	0.798	0.4272
FERT1	0.83545	0.048741	17.141	0
I1	0.18547	0.097042	1.911	0.0594
URB2	-0.00382	0.003442	-1.11	0.2704
GDPSQ	0.069789	0.052935	1.318	0.1910
LP-T2	-0.03586	0.036296	-0.988	0.3259
T&T	0.29431	0.40769	0.722	0.4724
COG	0.12496	0.41295	0.303	0.7629
JOR	0.28944	0.4344	0.666	0.5070
SOM	-0.03454	0.39963	-0.086	0.9313
RWA	0.60321	0.44037	1.37	0.1744
TOG	0.44681	0.40215	1.111	0.2697
MAU	-0.10049	0.42419	-0.237	0.8133
$\sigma = 0.3883$	RSS= 12.6			

Tests System 2

- correlation of URF residuals

	g2	I2	ENR22	FERT2
g2	1.000			
I2	0.3342	1.000		
ENR22	0.08491	0.2273	1.000	
FERT2	-0.08893	0.001206	0.04796	1.000

- standard deviations of URF residuals

g2	I2	ENR22	FERT2
0.02167	0.2884	0.2385	0.3883

- Loglik = 829.1811

- R^2(LR) = 0.999995 R^2(LM) = 0.816328

- F-test against unrestricted regressors, F(80, 321) = 86.541 [0.0000]

- correlation of actual and fitted

g2	I2	ENR22	FERT2
0.7279	0.9245	0.9737	0.9840

- **Diagnostic Tests**

g2	: AR 1- 2F(2, 82) =	2.0049 [0.1412]
I2	: AR 1- 2F(2, 82) =	2.0842 [0.1310]
ENR22	: AR 1- 2F(2, 82) =	0.31538 [0.7304]
FERT2	: AR 1- 2F(2, 82) =	0.0389 [0.9618]
g2	: Normality $Chi^2(2)$=	2.5836 [0.2748]
I2	: Normality $Chi^2(2)$=	7.097 [0.0288]
ENR22	: Normality $Chi^2(2)$=	4.8228 [0.0897]
FERT2	: Normality $Chi^2(2)$=	2.4503 [0.2937]
g2	: Xi^2 F(31, 52) =	1.1106 [0.3619]
I2	: Xi^2 F(31, 52) =	1.3235 [0.1830]
ENR22	: Xi^2 F(31, 52) =	1.7747 [0.0332]
FERT2	: Xi^2 F(31, 52) =	0.72456 [0.8303]

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Vector AR 1-2 F(32,270) = 1.0084 [0.4597]
Vector normality $Chi^2(8)$ = 15.365 [0.0524]
Vector Xi^2 F(300,445) = 0.70884 [0.9993]

Model 1

Modelling g3 by FIML. Sample is: 1 to 104

Equation for g3

Variable	Coefficient	Std.Error	t-value	t-prob	HCSE
OPEN3	6.39E-05	4.31E-05	1.482	0.1418	3.22E-05
GDP3	-0.05613	0.028447	-1.973	0.0516	0.028066
GDP3sq	0.002977	0.001791	1.662	0.1001	0.001813
IRQ	-0.0826	0.019171	-4.309	0	0.007704
BWA	0.092616	0.0184	5.034	0	0.0051
YEM	0.090751	0.018435	4.923	0	0.00586
UGA	0.079292	0.018168	4.364	0	0.004799
Constant	0.33186	0.1049	3.164	0.0021	0.10174
I3	0.001328	0.004476	0.297	0.7674	0.003841
fert3	-0.01428	0.002143	-6.664	0	0.002624
enr23	-0.00225	0.005198	-0.432	0.6667	0.005868
g2	0.13388	0.074087	1.807	0.0742	0.073452
URB3	-0.00022	0.000145	-1.539	0.1275	0.000142
VI3	0.009574	0.009202	1.04	0.301	0.009553
Venr23	-0.00795	0.012183	-0.653	0.5156	0.013316
Vfert3	-0.00157	0.006775	-0.232	0.8171	0.00658
σ = 0.0176					

Tests Model 1:

- Loglik = 428.52
- LR test of over-identifying restrictions: $Chi^2(7)$ = 3.68051 [0.8158]

- **Diagnostic tests:**

AR 1- 2F(2, 79) =	1.9946 [0.1429]
Normality $Chi^2(2)$=	1.332 [0.5138]
Xi^2 F(37, 43) =	0.55052 [0.9668]

Model 2

Estimating by OLS

Equation for g3

Variable	*Coefficient*	*Std.Error*	*t-value*	*t-prob*	*PartR²*	*Instab*
Constant	0.17299	0.033555	5.155	0	0.2168	0.1
I3	0.006322	0.003744	1.688	0.0946	0.0288	0.16
GDP3	-0.01562	0.003542	-4.411	0	0.1685	0.12
fert3	-0.01398	0.001894	-7.381	0	0.3621	0.1

Tests Model 2:

- $R^2 = 0.501956$
- F(3, 96) = 32.251 [0.0000]
- $\sigma = 0.0182067$
- DW = 2.09
- RSS = 0.0318225893 for 4 variables and 100 observations
- Variance instability test: 0.159626
- Joint instability test: 0.849248
- Information Criteria: SC = -7.86854; HQ = -7.93057; FPE = 0.000344745

- **Diagnostic Tests:**

AR 1- 2F(2, 94) =	1.3393 [0.2670]
Normality $Chi^2(2)$=	0.38977 [0.8229]
Xi^2 F(6, 89) =	1.0018 [0.4293]
Xi*Xj F(9, 86) =	0.84726 [0.5751]
RESET F(1, 95) =	3.2419 [0.0750]

Model 3

Estimating by OLS

Equation for g3

Variable	*Coefficient*	*Std.Error*	*t-value*	*t-prob*	*PartR²*	*Instab*
Constant	0.17716	0.03307	5.357	0	0.2358	0.07
I3	0.004195	0.003639	1.153	0.2519	0.0141	0.1
GDP3	-0.01479	0.003465	-4.267	0	0.1637	0.08
fert3	-0.01528	0.001965	-7.774	0	0.3939	0.04
AF	0.004757	0.008648	0.55	0.5836	0.0032	0.08
AS	0.008051	0.006893	1.168	0.2458	0.0145	0.1
LA	-0.01314	0.006303	-2.085	0.0398	0.0447	0.02

Tests Model 3:

- $R^2 = 0.583067$
- F(6, 93) = 21.676 [0.0000]
- $\sigma = 0.0169249$
- DW = 2.11
- RSS = 0.02663998485 for 7 variables and 100 observations
- Variance instability test: 0.310846
- Joint instability test: 1.09519
- Information Criteria: SC = -7.90815; HQ = -8.01671; FPE = 0.000306503

- **Diagnostic Tests**

AR 1- 2F(2, 91)	=	1.1012 [0.3369]
Normality $Chi^2(2)$	=	0.00383 [0.9981]
Xi^2 F(9, 83)	=	1.5878 [0.1323]
Xi*Xj F(21, 71)	=	0.9552 [0.5260]
RESET F(1, 92)	=	1.0258 [0.3138]

Model 4

Estimating by FIML. Sample : 1 to 104

Equation for g2

Variable	*Coefficient*	*Std.Error*	*t-value*	*t-prob*
Constant	0.40785	0.24673	1.653	0.1021
OPEN2	4.78E-05	6.48E-05	0.737	0.4630
GDP2	-0.08752	0.054593	-1.603	0.1127
LIFE2	0.000838	0.001284	0.653	0.5156
URB2	5.71E-05	0.000218	0.262	0.7937
GDPSQ	0.00439	0.003669	1.196	0.2350
T&T	0.047822	0.02407	1.987	0.0503
COG	0.057175	0.025063	2.281	0.0251
JOR	0.097197	0.024704	3.934	0.0002
SOM	0.059617	0.021827	2.731	0.0077
I2	-0.01421	0.013857	-1.025	0.3082
ENR22	0.0037	0.020275	0.182	0.8557
FERT2	-0.01561	0.029246	-0.534	0.5949
VI2	0.039088	0.016011	2.441	0.0168
VENR22	-0.00243	0.02248	-0.108	0.9142
VFERT2	0.010591	0.029818	0.355	0.7234
PI2	-0.00017	0.000113	-1.547	0.1257
IMORT2	8.34E-06	3.93E-05	0.212	0.8324
LP-T2	-0.0005	0.002295	-0.218	0.8279
ENR21	-0.00042	0.013786	-0.03	0.9758
g1	0.43983	0.11658	3.773	0.0003
FERT1	0.012202	0.024515	0.498	0.6200
$\sigma = 0.0206$				

Tests model 4:

- Loglik = 415.89938
- LR test of over-identifying restrictions: $Chi^2(1) = 0.686815$ [0.4072]
- **Diagnostic Tests**

AR 1- 2F(2, 79) =	1.8811 [0.1592]
Normality $Chi^2(2)$=	2.4999 [0.2865]
Xi^2 F(37, 43) =	1.0877 [0.3930]

Model 5

Estimating by FIML. Sample : 1 to 104

Equation for g2

Variable	*Coefficient*	*Std.Error*	*t-value*	*t-prob*
VFERT2	-0.00316	0.006808	-0.464	0.6440
VENR22	0.002016	0.01178	0.171	0.8645
OPEN2	6.23E-05	5.63E-05	1.108	0.2711
GDP2	-0.07246	0.042963	-1.687	0.0954
ENR22	0.006104	0.006463	0.945	0.3476
LIFE2	0.001286	0.000659	1.952	0.0542
IMORT2	-5.32E-06	3.81E-05	-0.139	0.8894
FERT2	-0.00204	0.003121	-0.655	0.5141
URB2	7.39E-05	0.000195	0.379	0.7058
Constant	0.31293	0.15386	2.034	0.0451
g1	0.38016	0.10467	3.632	0.0005
PI2	-0.00016	4.99E-05	-3.288	0.0015
T&T	0.037834	0.021424	1.766	0.0810
COG	0.054268	0.022053	2.461	0.0159
JOR	0.086177	0.024682	3.491	0.0008
SOM	0.048134	0.020863	2.307	0.0235
GDPSQ	0.003251	0.002798	1.162	0.2485
LP-T2	-0.00044	0.001999	-0.22	0.8265
I1	-0.0104	0.005156	-2.018	0.0468
$\sigma = 0.0215$				

Equation for I2

Variable	*Coefficient*	*Std.Error*	*t-value*	*t-prob*
VFERT2	-0.07219	0.089544	-0.806	0.4224
VENR22	0.35898	0.15789	2.274	0.0255
OPEN2	-0.00045	0.000751	-0.599	0.5505
GDP2	-0.07714	0.58046	-0.133	0.8946
ENR22	-0.08365	0.090903	-0.92	0.3601
LIFE2	0.014802	0.008608	1.72	0.0891
IMORT2	0.000371	0.000504	0.736	0.4638
FERT2	0.064978	0.041571	1.563	0.1218
URB2	0.00286	0.002532	1.13	0.2618
Constant	0.46572	2.0725	0.225	0.8227
g1	5.6416	1.4538	3.881	0.0002
PI2	-0.00294	0.000659	-4.46	0
JOR	0.57789	0.32801	1.762	0.0817
RWA	-0.80681	0.32387	-2.491	0.0147
TOG	0.64369	0.29071	2.214	0.0295
MAU	1.0825	0.28101	3.852	0.0002
GDPSQ	0.010441	0.037611	0.278	0.7820
LP-T2	0.028533	0.026181	1.09	0.2789
I1	0.47412	0.068961	6.875	0
$\sigma = 0.2819$				

Tests Model 5:

- Loglik = 557.89074
- LR test of over-identifying restrictions: $Chi^2(6) = 3.05949$ [0.8013]
- Correlation of residuals

	g2	I2
g2	1.000	
I2	0.3289	1.000

- **Diagnostic Tests:**

g2 : AR 1- 2F(2, 80) = 3.0077 [0.0550]
I2 : AR 1- 2F(2, 80) = 2.6632
[0.0759]
g2 : Normality $Chi^2(2)$ = 2.7785 [0.2493]
I2 : Normality $Chi^2(2)$= 7.6311 [0.0220]
g2 : Xi^2 F(35, 46) = 0.9699 [0.5324]
I2 : Xi^2 F(35, 46) = 1.0398 [0.4456]

Vector normality $Chi^2(4)$= 12.539 [0.0138]
Vector Xi^2 F(102,144) = 0.8898 [0.7337]

Model 6

Estimating by FIML. Sample: 1 to 104

Equation for g2

Variable	Coefficient	Std.Error	t-value	t-prob
VFERT2	-0.00378	0.006734	-0.561	0.5764
Constant	0.31339	0.1474	2.126	0.0363
PI2	-0.00016	4.92E-05	-3.322	0.0013
OPEN2	6.90E-05	5.53E-05	1.249	0.2149
GDP2	-0.07309	0.040684	-1.796	0.0759
ENR21	0.006536	0.004904	1.333	0.1861
g1	0.37946	0.10422	3.641	0.0005
LIFE2	0.001294	0.000648	1.998	0.0488
IMORT2	-3.11E-06	3.75E-05	-0.083	0.9340
FERT2	-0.00119	0.003081	-0.385	0.7011
URB2	0.000105	0.000189	0.558	0.5780
GDPSQ	0.003234	0.002645	1.223	0.2247
LP-T2	-0.00028	0.001984	-0.143	0.8869
I1	-0.01029	0.005052	-2.036	0.0448
T&T	0.039298	0.021011	1.87	0.0648
COG	0.057856	0.021252	2.722	0.0078
JOR	0.072597	0.022598	3.213	0.0018
SOM	0.048478	0.020556	2.358	0.0206
$\sigma = 0.021$				

Equation for I2

Variable	Coefficient	Std.Error	t-value	t-prob
VFERT2	-0.08527	0.091273	-0.934	0.3528
Constant	0.7333	2.08	0.353	0.7253
PI2	-0.00295	0.000675	-4.369	0
OPEN2	-0.00012	0.000743	-0.157	0.8759
GDP2	-0.23053	0.57363	-0.402	0.6888
ENR21	-0.03358	0.067301	-0.499	0.6191
g1	4.9469	1.4872	3.326	0.0013
LIFE2	0.015917	0.008592	1.852	0.0674
IMORT2	0.000305	0.000515	0.591	0.5561
FERT2	0.086167	0.040971	2.103	0.0383
URB2	0.002901	0.002529	1.147	0.2545
GDPSQ	0.019625	0.037207	0.527	0.5992
LP-T2	0.030083	0.02701	1.114	0.2684
I1	0.47765	0.070973	6.73	0
RWA	-0.67748	0.31234	-2.169	0.0328
TOG	0.52973	0.28267	1.874	0.0643
MAU	1.0223	0.29745	3.437	0.0009
$\sigma = 0.290$				

Equation for ENR22

Variable	*Coefficient*	*Std.Error*	*t-value*	*t-prob*
VFERT2	-0.01022	0.074992	-0.136	0.8919
Constant	-1.4795	1.716	-0.862	0.3909
PI2	0.00026	0.000556	0.468	0.6412
OPEN2	-0.00079	0.000612	-1.292	0.1998
GDP2	0.48846	0.47431	1.03	0.3059
ENR21	0.72512	0.055701	13.018	0
g1	2.5069	1.2371	2.026	0.0458
LIFE2	0.011785	0.007232	1.63	0.1068
IMORT2	0.000419	0.000424	0.988	0.3259
FERT2	0.039691	0.033805	1.174	0.2436
URB2	0.004386	0.002077	2.112	0.0375
GDPSQ	-0.03488	0.03075	-1.134	0.2598
LP-T2	0.005594	0.022177	0.252	0.8015
I1	-0.02337	0.058761	-0.398	0.6918
COG	0.55605	0.24472	2.272	0.0255
RWA	-1.0735	0.27152	-3.954	0.0002
TOG	0.87173	0.24577	3.547	0.0006
MAU	0.69584	0.25851	2.692	0.0085
$\sigma = 0.238$				

Tests model 6:

- Loglik = 715.84883
- LR test of over-identifying restrictions: $Chi^2(10) = 7.69721$ [0.6584]
- Correlation of residuals

	g2	I2	ENR22
g2	1.000		
I2	0.3430	1.000	
ENR22	0.09949	0.2519	1.000

- **Diagnostic Tests:**

g2	: AR 1- 2F(2, 81) =	2.6935 [0.0737]
I2	: AR 1- 2F(2, 81) =	3.3401 [0.0404]
ENR22	: AR 1- 2F(2, 81) =	1.8877 [0.1580]
g2	: Normality $Chi^2(2)$=	3.1806 [0.2039]
I2	: Normality $Chi^2(2)$=	5.7006 [0.0578]
ENR22	: Normality $Chi^2(2)$=	3.7124 [0.1563]
g2	: ARCH 1 F(1, 81) =	0.28408 [0.5955]
I2	: ARCH 1 F(1, 81) =	2.9627 [0.0890]
ENR22	: ARCH 1 F(1, 81) =	1.3844 [0.2428]
g2	: Xi^2 F(33, 49) =	0.8088 [0.7377]
I2	: Xi^2 F(33, 49) =	0.95277 [0.5517]
ENR22	: Xi^2 F(33, 49) =	0.77122 [0.7829]
Vector normality Chi^2(6)=		13.65 [0.0338]
Vector Xi^2 F(192,298) =		0.83803 [0.9082]

Model 7

Estimating the model by FIML. Sample: 1 to 104

Equation for g2

Variable	Coefficient	Std.Error	t-value	t-prob
Constant	0.17062	0.034805	4.902	0
PI2	-0.00012	3.90E-05	-3.165	0.0021
GDP2	-0.01965	0.004098	-4.795	0
ENR21	0.008442	0.003756	2.247	0.0269
g1	0.33844	0.091386	3.703	0.0004
FERT2	-0.00641	0.002062	-3.107	0.0025
T&T	0.047254	0.020298	2.328	0.022
COG	0.049049	0.020441	2.4	0.0183
JOR	0.08286	0.021399	3.872	0.0002
SOM	0.048078	0.020286	2.37	0.0198
$\sigma = 0.0215$				

Equation for I2

Variable	Coefficient	Std.Error	t-value	t-prob
PI2	-0.00215	0.000575	-3.739	0.0003
GDP2	0.18053	0.025992	6.946	0
g1	3.3013	1.335	2.473	0.0152
I1	0.55899	0.062383	8.961	0
RWA	-0.39425	0.30378	-1.298	0.1975
TOG	0.65088	0.2901	2.244	0.0272
MAU	1.0397	0.29438	3.532	0.0006
$\sigma=0.31$				

Equation for ENR22

Variable	Coefficient	Std.Error	t-value	t-prob
Constant	1.0476	0.06569	15.948	0
ENR21	0.74727	0.035655	20.958	0
g1	2.2478	0.99766	2.253	0.0265
URB2	0.002734	0.001554	1.759	0.0817
COG	0.52327	0.23227	2.253	0.0265
RWA	-1.0101	0.25149	-4.016	0.0001
TOG	0.82004	0.24149	3.396	0.001
MAU	0.65064	0.24958	2.607	0.0106
$\sigma = 0.2407$				

Tests: Model 7

- Loglik = 695.0469
- LR test of over-identifying restrictions: $Chi^2(38) = 49.3011$ [0.1036]
- Correlation of residuals

	g2	I2	ENR22
g2	1.000		
I2	0.3871	1.000	
ENR22	0.1257	0.3153	1.000

- **Diagnostic tests:**

g2	: AR 1- 2F(2, 81) =	8.974 [0.0003]
I2	: AR 1- 2F(2, 81) =	14.538 [0.0000]
ENR22	: AR 1- 2F(2, 81) =	7.783 [0.0008]
g2	: Normality $Chi^2(2)$ =	1.215 [0.5447]
I2	: Normality $Chi^2(2)$ =	0.388 [0.8236]
ENR22	: Normality $Chi^2(2)$ =	0.854 [0.6526]
g2	: Xi^2 F(33, 49) =	0.763 [0.7920]
I2	: Xi^2 F(33, 49) =	0.962 [0.5392]
ENR22	: Xi^2 F(33, 49) =	0.811 [0.7340]
	Vector AR 1-2 F(18,249) =	0.909 [0.5680]
	Vector normality Chi^2(6)=	3.081 [0.7986]
	Vector Xi^2 F(192,351) =	1.066 [0.3015]

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